7 A taxi firm is investigating replacing its drivers with self-driving cars.

(a) Explain why the self-driving system will use a real-time operating system.

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..... **[3]**

(b) The code for the self-driving system has been written using an object-oriented programming language.

It recognises obstacles in the road and then classifies them.
The class for `Obstacle` is shown below.

```
public class Obstacle
     private moving //Boolean value
     private distance //Real number given in metres
     private direction //Integer given as between 1 and 360 degrees

     public procedure new(givenMoving, givenDistance, givenDirection)
        moving=givenMoving
        distance=givenDistance
        direction=givenDirection
     endprocedure

     public procedure updateDistance(givenDistance)
            distance=givenDistance
     endprocedure

endclass
```

(i) Write a line of code to create an object called `bollard` of type `Obstacle` which is not moving and is 7.8 metres away in a direction of 8 degrees.

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..... **[2]**

(ii) Describe an example of encapsulation in the class definition code above.

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(iii) Describe the advantages of using encapsulation.

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..... **[2]**

(c) The self-driving program recognises people as a special type of obstacle and the class `Person` should inherit the methods and attributes of `Obstacle`. People are treated like other obstacles except:

- when the `updateDistance` method is called, if the person is more than 2 metres away but is 5 metres (or less) away, the method `Controls.beepHorn()` is called.
- when the person is 2 metres away (or closer), the method `Controls.applyBrakes()` is called as well as `Controls.beepHorn()`.

Complete the class `Person`.

```
class Person .....

     public procedure updateDistance(givenDistance)

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          distance=givenDistance
     endprocedure
endclass
```

[5]

(d) Give **one** advantage and **one** disadvantage to the customers of the taxi using self-driving cars rather than drivers.

Advantage

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Disadvantage

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[2]

8 A student writes a program to apply a symmetric encryption algorithm to work on messages of up to 25 ASCII characters.

(a) Describe what is meant by the term 'ASCII'.

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..... **[2]**

The encryption algorithm works in the following way.
A message of up to 25 characters (spaces and punctuation are not included) is placed in a 5×5 array. Any leftover spaces are filled with random letters. The message I LOVE COMPUTER SCIENCE becomes:

I	L	O	V	E
C	O	M	P	U
T	E	R	S	C
I	E	N	C	E
T	O	W	R	M

The key is a sequence of ten numbers.
In this example we will use `1 2 3 4 5 1 2 3 4 5`. The first 5 numbers state how many spaces the rows 0 to 4 must be rotated right.

A key with the first 5 digits `1 2 3 4 5` would result in

E	I	L	O	V
P	U	C	O	M
R	S	C	T	E
E	N	C	E	I
T	O	W	R	M

The next 5 digits state how many spaces down the columns 0 to 4 should be rotated.

Applying the last 5 digits `1 2 3 4 5` to the grid above would give

T	N	C	O	V
E	O	C	T	M
P	I	W	E	E
R	U	L	R	I
E	S	C	O	M

Part of the pseudocode for the algorithm is written below.

```
global array grid[5,5]
addMessage()
// letters and random letters have been entered
// into the 2D array, grid

for i = 0 to 4
     x = getNextDigitInKey()
     shiftRow(i,x)
next i

for i = 0 to 4
     x = getNextDigitInKey()
     shiftColumn(i,x)
next i

//Now reassemble array back into string.
```

(b) Show the result of running the algorithm on the grid and key below. **[2]**

KEY: 3 3 3 3 3 1 1 1 1 1

T	O	P	S	E
C	R	E	T	M
E	S	S	A	G
E	Y	R	P	L
U	O	G	G	Q

Grid after only the rows are shifted:

Grid after columns have also been shifted:

(c) Write the procedure `shiftRow`.

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..... **[4]**

(d)* Modern encryption is much stronger than the method described in the first part of this question.

Discuss the impact of modern encryption on society. You should refer to:

- The importance of asymmetric encryption and how it differs from symmetric encryption.
- Different circumstances in which symmetric and asymmetric encryption may be used.

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..... **[9]**

9 **(a)** Demonstrate how the bytes below are added together. Show your working.

01101010
00111111+

[2]

(b) Demonstrate how the bottom byte below is subtracted from the top byte. Show your working.

11001111
00111001 -

[2]

(c) Convert the binary number shown below to hexadecimal.

0011011100001111

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..... **[2]**

(d) The number below is represented in floating point format with a 5-bit mantissa in two's complement followed by a 3-bit exponent in two's complement. Calculate the denary value of the number, showing your working.

01001 010

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..... **[3]**

(e) The numbers below are represented in floating point format with a 5-bit mantissa in two's complement followed by a 4-bit exponent in two's complement. Normalise the numbers shown below, showing your working.

00011 0010

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..... **[2]**

11100 0110

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..... **[2]**

(f) Show the byte below after having an AND applied with the masking byte.

Byte	1	0	1	1	1	0	0	1
AND	1	1	1	1	1	1	1	1
Result								

[1]

(g) Show the byte below after having an OR applied with the masking byte.

Byte	1	0	1	1	1	0	0	1
OR	1	1	1	1	1	1	1	1
Result								

[1]

10 (a) Draw a logic gate diagram to represent the Boolean expression

$Q \equiv \neg A \vee B$

[2]

(b) Find the Boolean expression represented in the Karnaugh Map below. Show your working.

CD \ AB	00	01	11	10
00	1	1	1	1
01	0	0	1	1
11	0	0	0	1
10	0	0	0	1

[5]

END OF QUESTION PAPER